(54) Title: ADAPTIVE PILOT/TRAFFIC CHANNEL POWER CONTROL FOR 3GPP WCDMA
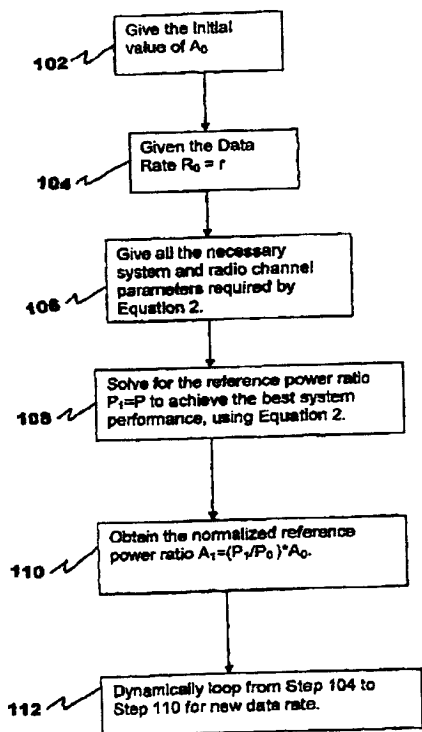
(57) Abstract: The present invention is a method (figure 1) and system to determine the gain factors for the uplink and downlink Dedicated Physical Control Channel (DPCC) and Dedicated Physical Data Channel (DPDC). The method consists of determining new data rate (104) for transmission; providing corresponding system and radio channel parameters (106); determining reference power ratio P1 (108); and, normalizing the reference power ratio (110).

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

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ADAPTIVE PILOT/TRAFFIC CHANNEL POWER CONTROL FOR 3GPP WCDMA

FIELD OF THE INVENTION

This invention relates to the field of wireless digital communications, and more

5 particularly to gain factors.

BACKGROUND OF THE INVENTION

Wireless communications facilitates the delivery of information between the transmitter and the receiver without a physical wired connection. Such advantage translates to the freedom of mobility for the users and to the savings of wiring nuisance

10 for the users. However, spectrum has become scarce resource as the usage of wireless communications for various applications becomes more popular. Therefore the efficiency of using spectrum presents challenges for the wireless industry. In order to maximize efficient spectrum utilization, various multiple access methods have been proposed to achieve the goal.

15 First generation cellular communications systems, Advanced Mobile Phone Services (AMPS) employed the Frequency Division Multiple Access (FDMA) method and provided voice communication services in the early days. Second generation cellular communications systems improved the spectrum efficiency by using more digital processing of signals and employed Time Division Multiple Access (TDMA) method in

20 GSM and IS-136 systems and Code Division Multiple Access (CDMA) method in IS-95 systems. While second generation systems typically provide two to five times voice capacity over the first generation systems, data capabilities of second-generation systems are very limited.

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are very limited.

Recent rapid commercial development of Internet and multimedia applications has created a strong demand for wireless cellular systems capable of providing sufficient bandwidth. In addition, further improvement of voice capacity in spectrum efficiency is in great demand as the spectrum allocated for service is very limited. This scarcity

5   results in high licensing fees for the available spectrum.

Therefore there is a strong need to improve the system capacity and spectrum efficiency for wireless communication systems.

SUMMARY OF THE INVENTION

The present invention is a method and system to determine the gain factors for

10   the uplink and downlink Dedicated Physical Control Channel (DPCC) and Dedicated Physical Data Channel (DPDC).

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the present invention may be obtained from consideration of the following description in conjunction with the drawing in which Fig.

15   1 is a functional block diagram.

DETAILED DESCRIPTION OF AN EXEMPLARY EMBODIMENT

The present invention is equally well suited for both uplink of WCDMA as well as other similar systems like CDMA2000. One feature of the present invention is a method and system to determine the gain factors for the uplink and downlink DPDCH

20   and DPCCH. This method and system is equally well suited for Physical Random Access Channel (PRACH) message part.

The uplink Dedicated Physical Control Channel (DPCCH) and Dedicated Physical Data Channel (DPDCH) are transmitted on different codes. The gain factors β_c and β_d are important to 3GPP WCDMA system performance like capacity.

The initial uplink DPCCH transmit power is set by higher layers. Subsequently the uplink transmit power control procedure simultaneously controls the power of a DPCCH and its corresponding DPDCHs (if present). The relative transmit power offset between DPCCH and DPDCHs is determined by the network and is computed using the gain factors signaled to the User Equipment (UE) using higher layer signaling.

There are two ways of controlling the gain factors of the DPCCH code and the DPDCH codes for different Transport Format Combinations (TFCs) in normal (non-compressed) frames:

- β_c and β_d are signalled for the TFC, or

- β_c and β_d is computed for the TFC, based on the signalled settings for a reference TFC.

Combinations of the two above methods may be used to associate β_c and β_d values to all TFCs in the TFCS. The gain factors may vary on radio frame basis (1 radio frame = 10 ms) depending on the current TFC used. Further, the setting of gain factors is independent of the inner loop power control.

The operation of the inner power control loop, adjusts the power of the DPCCH and DPDCHs by the same amount, provided there are no changes in gain factors. Additional adjustments to the power of the DPCCH associated with the use of compressed mode. Any change in the uplink DPCCH transmit power shall take place

immediately before the start of the pilot field on the DPCCH. The change in DPCCH power with respect to its previous value is derived by the User Equipment and is denoted by Δ_{DPCCH} (in dB). The previous value of DPCCH power shall be that used in the previous slot, except in the event of an interruption in transmission due to the use of

5   compressed mode, when the previous value shall be that used in the last slot before the transmission gap.

During the operation of the uplink power control procedure the User Equipment transmit power·shall not exceed a maximum allowed value which is the lower out of the maximum output power of the terminal power class and a value which may be set by

10   higher layer signaling. Uplink power control shall be performed while the User Equipment transmit power is below the maximum allowed output power. If the User Equipment transmit power is below the required minimum output power [as defined in TS 25.101] and the derived value of Δ_{DPCCH} is less than zero, the User Equipment may reduce the magnitude of Δ_{DPCCH}.

15   The User Equipment shall scale the total transmit power of the DPCCH and DPDCH(s), such that the DPCCH output power follows the changes required by the power control procedure with power adjustments of Δ_{DPCCH} dB, unless this would result in a User Equipment transmit power above the maximum allowed power. In this case the User Equipment shall scale the total transmit power so that it is equal to the

20   maximum allowed power.

The gain factors during compressed frames are based on the nominal power relation defined in normal frames.

When the gain factors β_c and β_d are signaled by higher layers for a certain TFC, the signaled values are used directly for weighting of DPCCH and DPDCH(s). The variable A_j, called the nominal power relation is then computed as:

$$A_j = \frac{\beta_d}{\beta_c}$$
Equation 1.

5   Typically each TFC has a unique data rate connected with a unique pair of gain factors for the DPCCH and DPDCH. The change of gain factors for DPCCH and DPDCH are performed to keep constant the transmitted bit energy E_b (before coding) on the DPDCH, independent of the data rate. The DPCCH power is kept constant to avoid affecting the transmit power control (TPC). If the power ratio between DPDCH and

10 DPCCH goes wrong, the TPC loop operating based on DPCCH will degrade the WCDMA system performance.

The present invention provides a method and system to determine the gain factors for the uplink DPDCH and DPCCH.

$$\gamma_b = \frac{m(P+1)}{R_0 P}\left(\frac{1}{\sqrt[r_0]{2^{1-r_0}-1}}-1\right) \times \left(\frac{1}{2}+\sqrt{\frac{1}{4}+\frac{2R_0 P B_n/R_b}{(1+2R_0 P B_n/R_b)^2}\left(\frac{\sqrt[R_0]{2^{1-R_0}-1}}{1-\sqrt[R_0]{2^{1-R_0}-1}}\right)}\right)$$
Equation 2.

15 In Equation 2, m represents number of paths, P represents reference power ratio, R_0 represents cutoff rate, r_0 represents coding rate, B_n represents the noise bandwidth, and, R_b represents information bit rate. A key concept of the present invention is to link up the nominal power relation in Equation 1 with both system and radio channel parameters through the closed form relationship given by Equation 2.

20 Referring to the functional diagram in Fig. 1 there can be seen an illustration of the use of the present invention in the form of a functional block diagram to set up the

normalized reference power ratio. By using an example the working principle behind the present invention can be better illustrated. In Step 102 we use the corresponding reference power ratio for voice (Most times the system parameters are optimized for voice performance and for a WCDMA system the initial focus is voice applications) as

5   the initial value of P_0. When the system is required to serve a new data rate, say r=384kbps, we need to figure out what the new nominal power relation in Equation 1. The method illustrated in Fig. 1 is used to obtain the new A_1. This new A_1 can be used by the system to set up the signaled gain factors for the reference TFC. The settings can be sent through higher layers for a certain TFC. What really matters is the relative settings

10 of one data rate to another initial data rate such as a voice channel. The relative settings play an important role in "calibrating" the system settings. If there is a system error in Equation 2, this scaling can reduce the error such that the relative settings can more accurately describe the functional relationship between one DPDCH data channel and another DPDCH data channel.

15   In step 102 an initial value is given to A_0. The data rate in step 104 is given. In step 106 the necessary system and radio channel parameters necessary for Equation 2 are given. The reference power ratio $P_1=P$ is solved using Equation 2 in step 108. The normalized reference power ratio is determined in step 110. Steps 104 through 110 are dynamically repeated for new data rate.

20   In the present invention, the dynamic nature of the radio channel is directly related to the dynamic nature of the DPDCH data channel. Therefore the present invention responds quickly to the radio channel of the air interface while the mobile terminal is moving around. No simple scheme in power settings can be accurate without

dynamic response to the real-time radio channel being experienced by the DPDCH data channel and the DPCCH channel. Thus this scheme can be regarded as the adaptive scheme for the system to set up the resources to make certain that the WCDMA system works at an optimal state.

5   The significance of this method is the speed of the quick convergence. Although it may not be so accurate for some working conditions, the method is Fig. 1 dynamically adjust the nominal power relation quickly. Thus the system is always working at the quasi-optimal system settings. One result of the net advantages of this method is that the system resource or system power is not wasted and thus the interference is minimized.

10   These two interacting factors both lead to higher system throughput or system capacity.

In view of the foregoing description, numerous modifications and alternative embodiments of the invention will be apparent to those skilled in the art. The present invention is equally well suited for both uplink of WCDMA and similar systems like CDMA2000. One feature of the present invention is a method and system to determine

15   the gain factors for the uplink and downlink DPDCH and DPCCH. This method and system is equally well suited for Physical Random Access Channel (PRACH) message part. Accordingly, this description is to be construed as illustrative only and is for the purpose of teaching those skilled in the art the best mode of carrying out the invention. Details of the structure may be varied substantially without departing from the spirit of

20   the invention, and the exclusive use of all modifications, which come within the scope of the appended claim, is reserved.

I claim:

1.   A method for adaptive pilot/traffic channel power control in a CDMA

communication system, the method comprising the following steps:

5   determining new data rate for transmission;

        providing corresponding system and radio channel parameters;

        determining reference power ratio P_1; and,

        normalizing the reference power ratio.

10   2.   The method as recited in claim 1 further comprising the step of assigning an

initial power ratio A_0.

3.   The method as recited in claim 2 wherein said initial power ratio A_0 is for voice.

15   4.   The method as recited in claim 1 wherein the reference power ratio is determined

by

$$T_b = \frac{m(P+1)}{R_0 P} \left(\frac{1}{\sqrt[n]{2^{1-r_0}} - 1} - 1 \right) \times \left(\frac{1}{2} + \sqrt{\frac{1}{4} + \frac{2R_0 P B_n / R_b}{(1 + 2R_0 P B_n / R_b)^2} \left(\frac{\sqrt[n]{2^{1-R_0}} - 1}{1 - \sqrt[n]{2^{1-R_0}} - 1} \right)} \right)$$

wherein m represents number of paths; P represents reference power ratio; R_0

represents cutoff rate; r_0 represents coding rate; B_n represents the noise bandwidth; and,

20   R_b represents information bit rate.

5.   The method as recited in claim 1 wherein the normalized reference power ratio is

determined by $A_1 = (P_1/P_0)*A_0$.

6.   The method as recited in claim 1 further comprising repeating the steps for each

new data rate.

5   7.   The invention as substantially described and shown herein.

102 [Box: Give the initial value of A_0]

104 [Box: Given the Data Rate $R_0 = r$]

106 [Box: Give all the necessary system and radio channel parameters required by Equation 2.]

108 [Box: Solve for the reference power ratio $P_1=P$ to achieve the best system performance, using Equation 2.]

110 [Box: Obtain the normalized reference power ratio $A_1=(P_1/P_0)^*A_0$.]

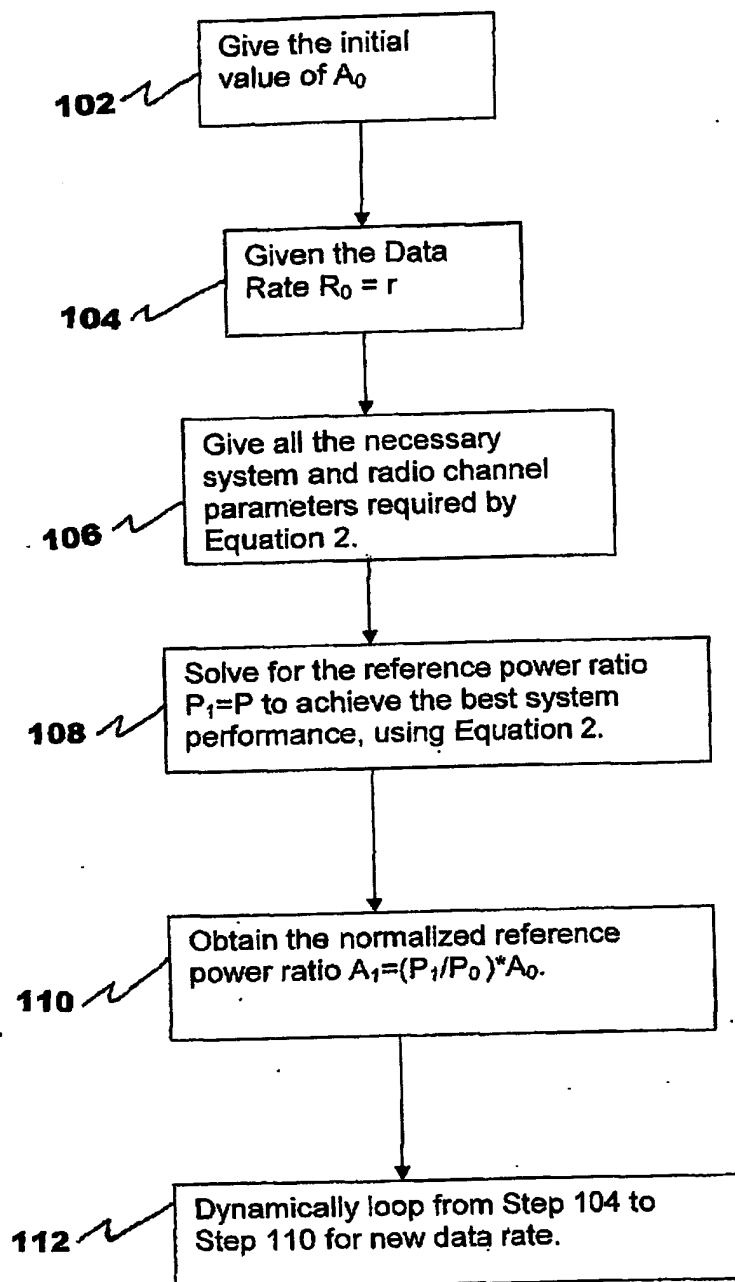**112** [Box: Dynamically loop from Step 104 to Step 110 for new data rate.]

Fig. 1

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US01/50552

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :H04B 15/00; H04K 1/00; H04L 27/30

US CL :375/130

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 375/130

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EAST (power control, data rate, bit rate, bandwidth, normalizing)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6,111,857 A (SOLIMAN et al.) 29 AUGUST 2000, columns 1-3.	1-7
Y	US 5,862,453 A (LOVE et al.) 19 JANUARY 1999, abstract, figures 6 and 8 and entire desclosure.	1-7
Y	US 5,267,262 A (WHEATLEY, III) 30 NOVEMBER 1993, abstract, col. 4, line 21-col. 9, line 21, and claims 1-19.	1-7

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 MARCH 2002	12 APR 2002
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer MOHAMMAD GHAYOUR Telephone No. (703) 305-3034

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